EVOLUTION

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Evolution :

- Study of history of life forms on earth
- Origin of life:
- Universe- 20 billion years old (big bang theory – single huge explosion, unimaginable in physical terms)
- Earth – 4.5 billion years ago
- First non cellular life (as RNA and proteins) - 4.0 billion years ago, i.e. 500 million years after formation of earth
- First cellular life (heterotrophic, anaerobic prokaryotic cell)- about 2 bya/2000 millions years ago
- First Eukaryotic cell – 1.5 billion years ago

Conditions at time of origin of life –

1) **high temperature (800-900^{o}C)**
2) **heavy metals at core – Fe, Ni**
3) **gases – CH_4, NH_3, hydrogen, helium, water vapours**
4) **Volacanic storms**
5) **UV rays – no ozone layer, no free oxygen (reducing atmosphere)**

Hypothesis related to origin of life on earth

1. **Theory of Special Creation- by Father Suarez**
2. **Theory of Catastrophism – By Cuvier**
3. **Cosmozoic theory/Panspermia – units of life called "spores" were transferred to different planets including earth**
4. **Theory of Abiogenesis/Spontaneous generation – by Von Helmont**
   - ✓ **Life came out of decaying and rotten matter like straw, mud**
5. **Theory of Biogenesis – life from life (proved by Redi-1668, Spallanzani 1767 and Louis Pasteur by "swan neck flask experiment")**

- ✓ **Pasteur dismissed spontaneous generation theory once and for all. He showed that in pre-sterelised flasks, life did not come from killed yeast while in another flasks open to air, new living organisms arose from killed yeast**

6. **Theory of Chemical evolution (most accepted)**
   - ✓ **Oparin of Russia and Haldane of England, proposed that the first form of life could have come from pre existing non - living organic molecules (Protein, RNA etc.) and that formation of life was preceded by chemical evolution i.e. formation of diverse organic molecules from inorganic constituents**

Chemical Evolution

Free atoms — **H, C, N, O, etc.**

↓

Inorganic molecules — **H_2, NH_3, Co_2, H_2O**

(in atmosphere & Hydrosphere)

UV-rays + In Hot water of Primitive Ocean

↓

Simple organic molecules — **Alcohol, Aldehyde, Ketone, Ethylene**

↓

First Biomolecules — **Simple sugar & Amino acids**

↓ **Polymerization**

Polysaccharides, Proteins, Fatty acids

↓

Lipids, Nitrogen bases

↓

Nucleotide

↓

RNA 1st Sign of Life — **(Self-replicating, Catalyse reaction)**

↓ ↓

1st non-cellular Life/Eobiont — **DNA** — **1st cell**

(RNA + Protein = Ribonucleoprotein) ⟹ Prokaryote ⟹ Eukaryote

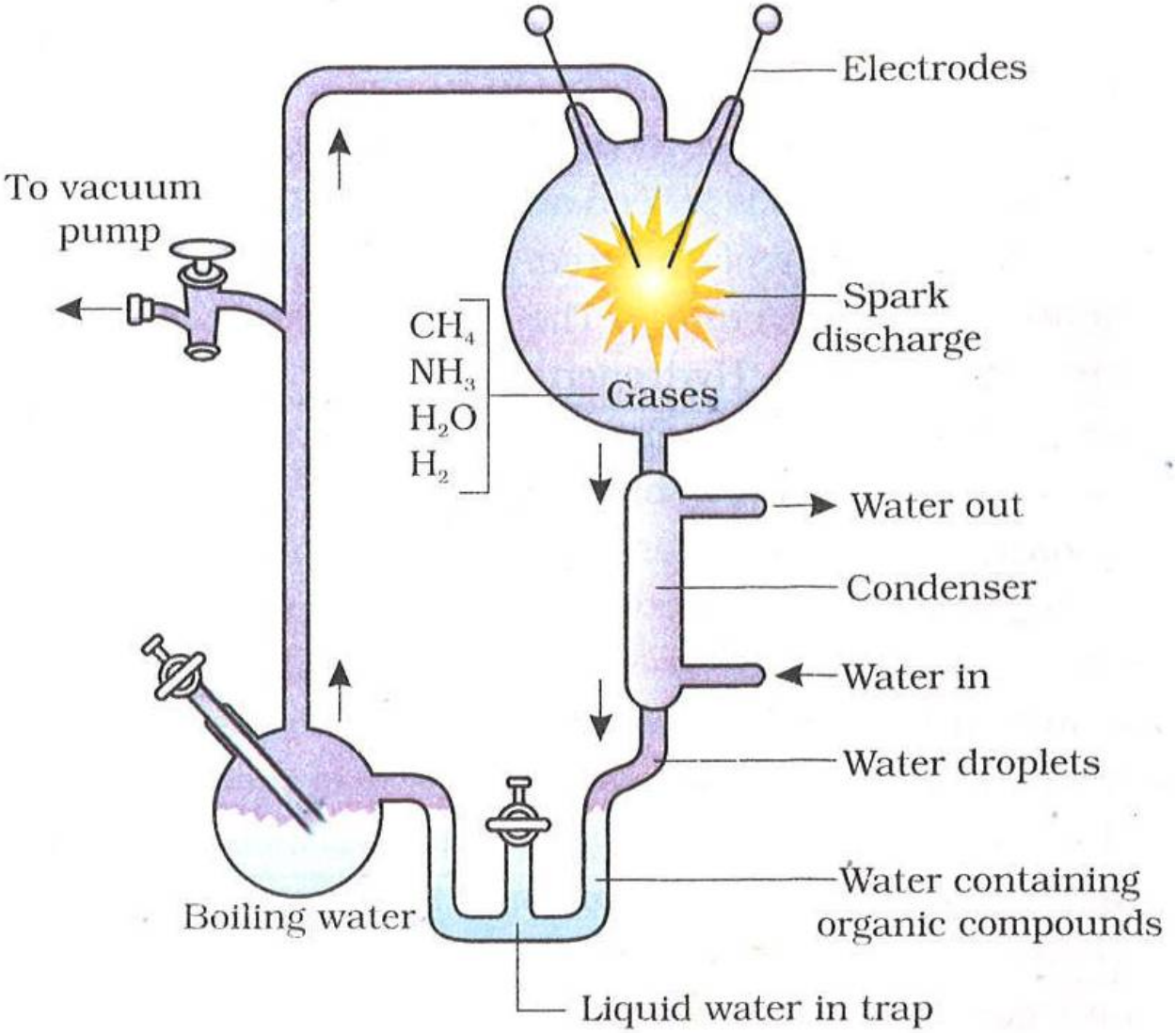
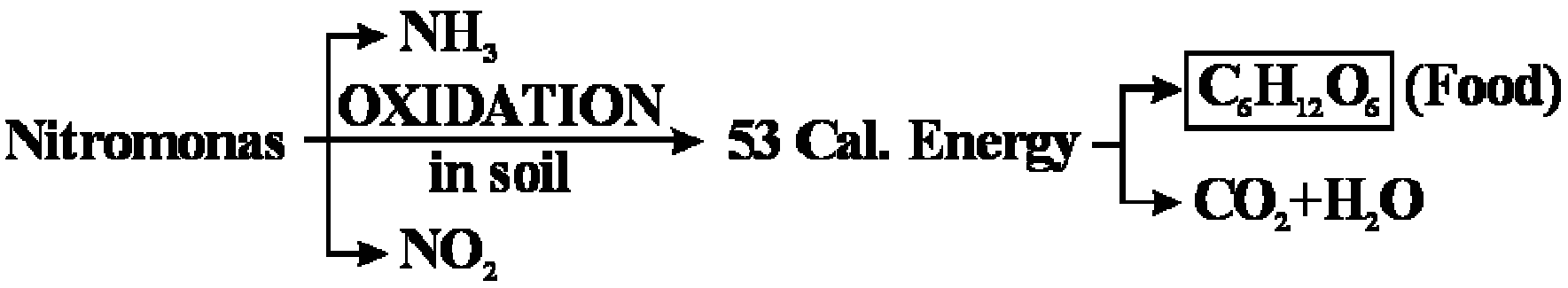


Figure 7.1 Diagrammatic representation of Miller's experiment

- **Energy sources – solar UV rays, lightening, volcanic heat**
- **Stanley Miller – experimental evidence of chemical evolution (1953):**
- **Hydrogen : Ammonia:methane = 2:1:2**
- **Super heated steam at 800^{o}c**
- **75000 volt current for 18 days**
- **Amino acids found – alanine, glycine, aspartic acid.**
- **Protobiont (precursors of cells) experiment – coacervates (Oparin) and microspheres (Sydney fox)- colloidal proteins/particles, precursors of first cells.**
- **First organism – anaerobic heterotrophic**

- **CHEMOAUTOTROPHS – Anaerobic**



- **ANOXYGENIC PHOTOSYNTHESIS -**

$$CO_2 + H_2S \xrightarrow[\text{Bacteriochlorophyll}]{\text{Sunlight}} \underset{\text{(Food)}}{\boxed{C_6H_{12}O_6}} + S\uparrow$$

- **OXYGENIC PHOTOSYNTHESIS -**

$$CO_2 + H_2O \xrightarrow[\text{Chlorophyll A/B}]{\text{Sunlight}} \underset{\text{(Food)}}{\boxed{C_6H_{12}O_6}} + O_2\uparrow$$

- **First autotroph – chemosynthetic bacteria eg. Nitromonas, Nitrobacter**
- **Photosynthetic bacteria – developed bacteriochlorophyll, started "anoxygenic photosynthesis. Eg purple and green – sulphur bacteria "**
- **Oxygenic photosynthesis – origin of BGA/cyanobacteria (chlorophyll A and B)**
- **Addition of O_2 / atmosphere converted to "oxidative type"**
- **Formation of ozone (o_3) layer**
- **UV rays entry checked, chemical evolution stopped, only biological evolution going on**

Theories of biological evolution:

1. **Lamarckism/theory of acquired inheritance/ theory of use and disuse of organ – by J.B.de Lamarck (French)**
   - ✓ **“Philosophie zoologique (book, published in 1809)**
   - ✓ **Two key concepts – ever changing environment, use and disuse of organs**
   - ✓ **Eg. Long neck in giraffe (due to continuous stretching to forage leaves on tall trees)**

2. **Weisman's theory of "continuity of germplasm" - criticized Lamarckism**
   - ✓ **Cut tails of mice for 22 generations, 23 generations still had full length tail**
   - ✓ **Only the changes that effect germ plasma (forms gametes) are inheritable**
3. **Darwinism/theory of natural selection-**
   - ✓ **Jointly proposed by Charles Darwin(1809-1882) and A.R. Wallace**
   - ✓ **Book – Origin of species by Darwin, published in 1859**
   - ✓ **Darwin visited Galapagos Island (pacific ocean) by H.M.S Beagle ship**
   - ✓ **Wallace visited Malaya island (Malay archipelago)**

- **Ispired by “essay on population by T.R.malthus”**
- **Population growth exponential, food production airthmatic progression**
- **Darwin studied about 20 species of “finch birds”, with different feeding habits and different beak structure, evolved from a single seed eating ancestors (islands – living factory of evolution)**
- **Two key concepts - Branching descent and natural selection**

Main points of Darwinism –

1. **Enormous power of reproduction – over sized population**
2. **Limited natural resources – inter and intra specific competition – “struggle for existence”**
3. **Inbuilt variations in individuals of a species (no two individuals are alike), most of variations are inherited**
4. **Ability to adapt - Natural selection – survival of the fittest**
   - ✓ **Helpful variations for survival and higher reproduction rate – called “adaptation”**

- ✓ **“adaptations have genetic basis i.e they are always inheritable (may arise spontaneously, as shown by Lederberg and Lederberg replica plating experiment – spontaneous mutation)”**
- ✓ **Ability to adapt – fitness – reproductive fitness (high rate of reproduction)**

5. **Speciation (formation of new species – by accumulation of “adaptive variation”)**

Demerits –

1. **Did not consider discontinuous variations (mutations)**
2. **didn't sources of variation in species (pangenesis theory rejected)**
3. **Explains survival of fittest but not arrival of fittest**
4. **Considered "species" - as unit of evolution (population is the unit)**
5. **Could not explain presence of supe - specialized characters/ vestigial organs.**

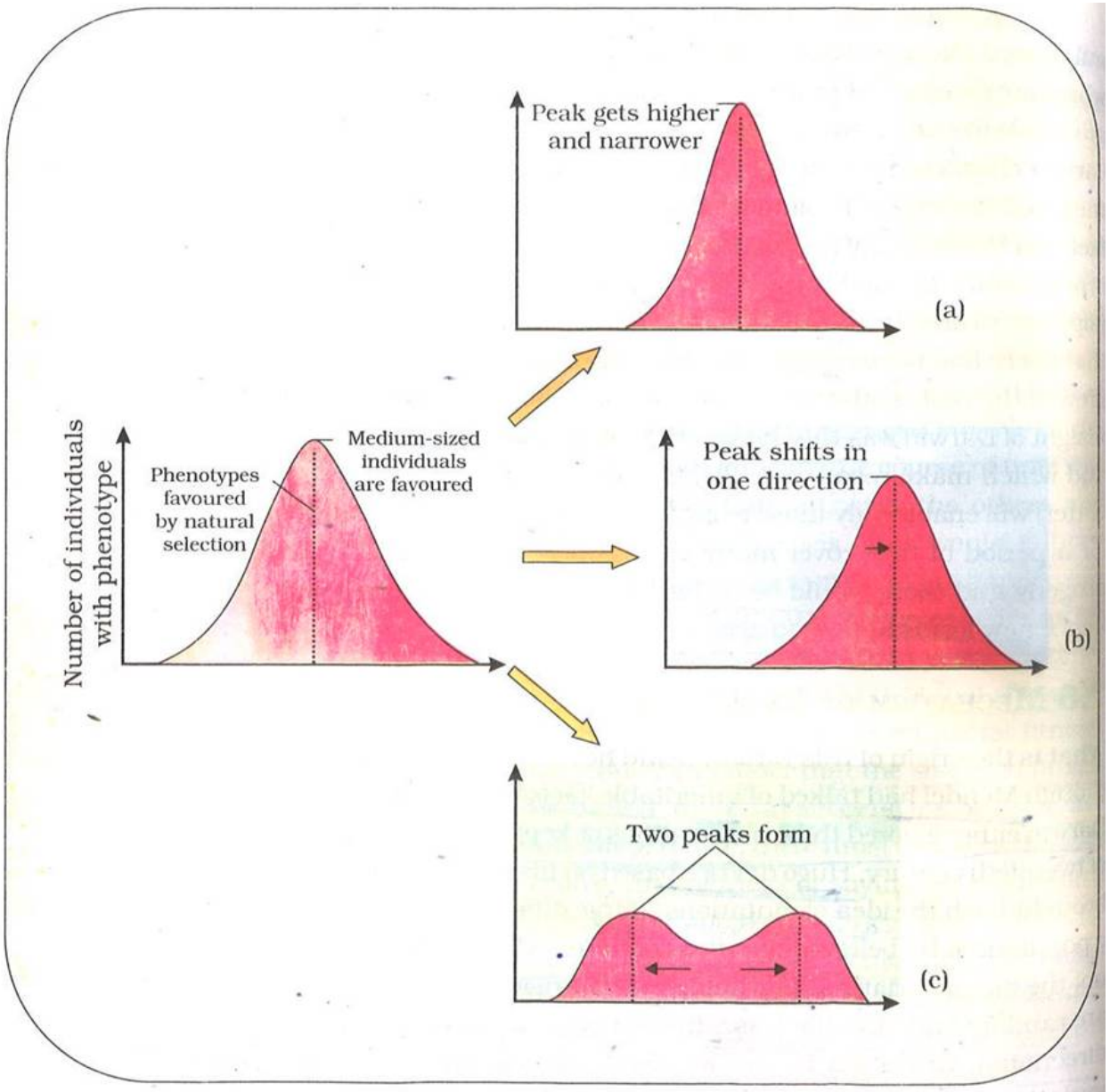


Figure 7.8 Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

Types of natural selection –

1. **Stabilizing – most common type, nature selects "mean value", taller and narrower peak, operates in constant environment, eg. survival of heterozygous sickle cell trait individuals in malaria infested regions**
2. **Directional/progressive selection-under changing environment, selects one extreme value over another, peak shifts in one direction, Eg - Industrial melanism in peppered moth (UK)**
3. **Disruptive selection - rare, selects both extreme value, two peeks obtained eg. shell patterns of limpids**

Examples in support of natural selection –

a) **Industrial melanism**
b) **DDT resistant mosquitoes**
c) **Sickle cell anemia**
d) **Antibiotic resistance in bacteria/ Lederberg replica plating experiment**
e) **Artificial selection**

4. **Mutation theory/ Saltation theory – by Hugo de Vries**
   - ✓ **Evening primerose plant (Oenothera lamarckiana)**
   - ✓ **Sudden change in phenotype of an individual are – mutation (large discontinuous sudden differences)**
   - ✓ **Mutations are random and directionless, variations (Darwin) are small and directional**
   - ✓ **Evolution for Darwin – gradual**

(a) (b)

Figure 7.4 Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk (a) In unpolluted area (b) In polluted area

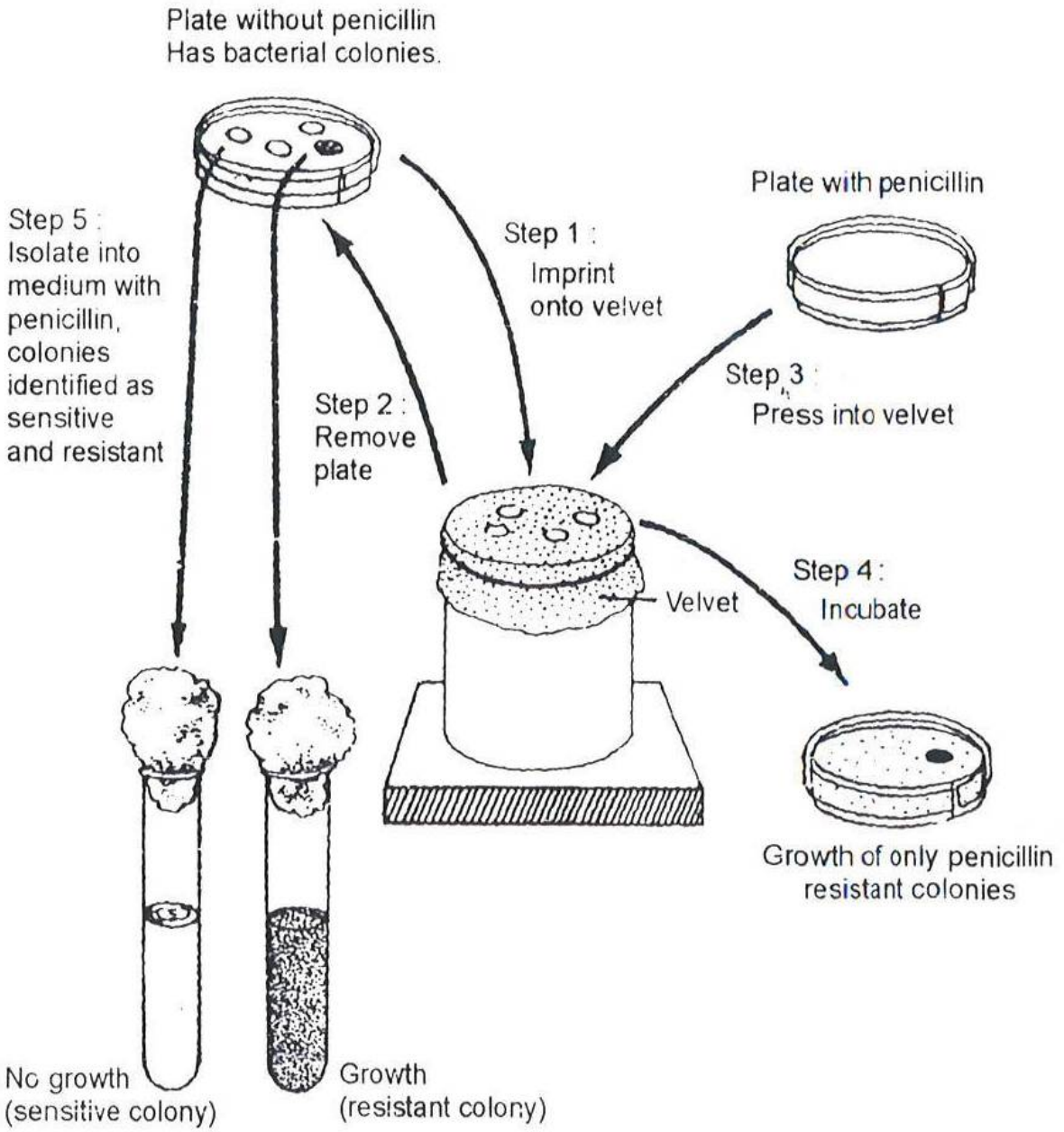


Fig. : Lederberg's replica plating experiment

- ✓ **Evolution for de Vries – single step/saltation (mutation causes speciation)**
- ✓ **Mutations – mainly recessive, mostly harmful (one out of 10000 is useful)**

5. **Neo-Darwinism/ The Modern Synthetic theory-**
   - ✓ **Two key concepts – mutations, natural selection**
   - ✓ **Unit of evolution – population**
   - ✓ **Gene pool – all the genes and the alleles in a population together**
   - ✓ **Any change in gene/ allele frequency of population – reflected as evolution**
   - ✓ **Factors effecting gene pool- gene mutations, gene migrations/ gene flow ,genetic recombination (crossing over), genetic drift, natural selection, reproductive isolation etc**

- **Genetic drift/ Sewall Wright effect – sudden change in gene frequency of a small population, due to chance factor**

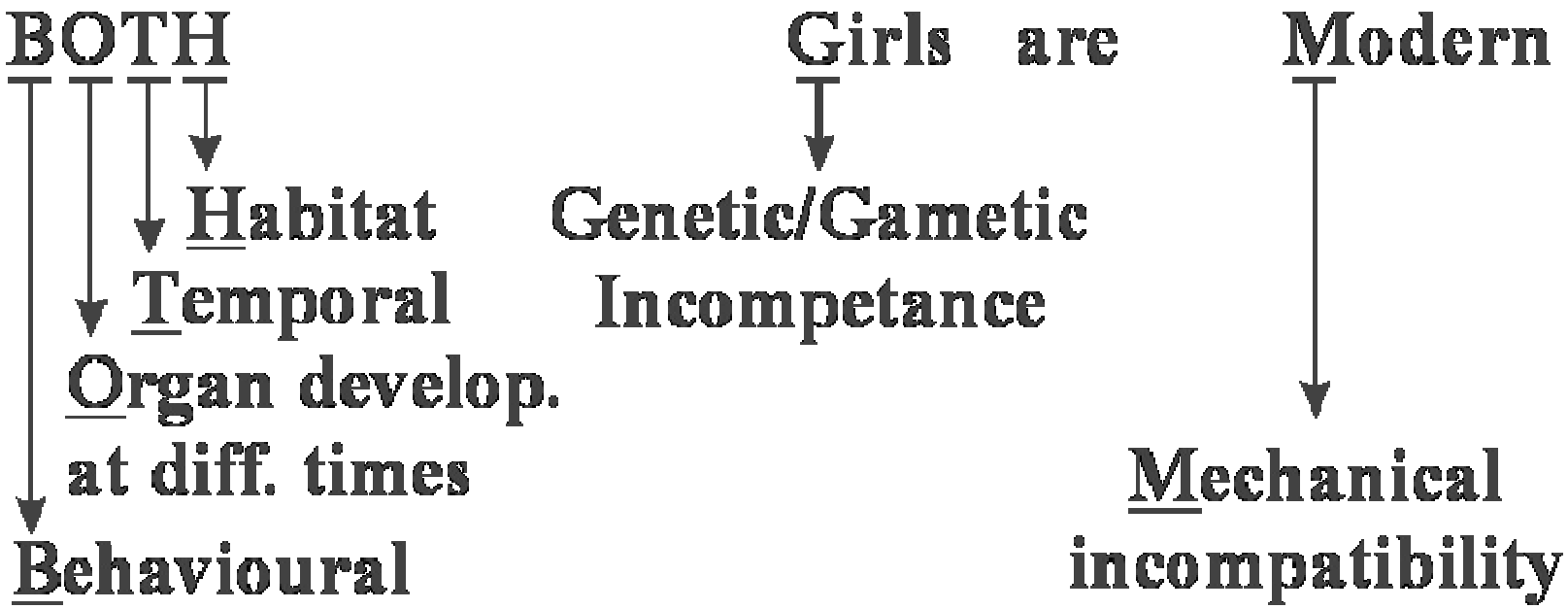
1. **Bottle neck effect – disappearance of an allele from population by catastrophic event or uncontrolled hunting**
2. **Founder effect**
   - ✓ **Hardy – Weinberg's equilibrium law/ principle-**
   - ✓ **"allele frequencies in a population are stable and constant from generation to generation/gene pool remains constant, in a randomly mating population"**
   - ✓ **Some total of all allelic frequencies = 1**

- ✓ **P^2+ 2pq+q^2=1, where p= frequency of dominant allele A, q= frequency of recessive allele a, p^2 = frequency of individuals AA (dominant homozygous), q^2 = frequency of aa individuals (recessive homozygous), 2pq = frequency of Aa individuals (heterozygous individuals)**
- ✓ **Factors effecting – gene migration/flow, mutation, genetic drift, genetic recombination, natural selection**

Speciation – two types

1. **Allopatric – geographical isolation, time taking**
2. **Sympatric – new species formation within a single population without geographical isolation, instant process, mainly in plants, polyploidy**

Trick :- Speciation (Pre-mating)



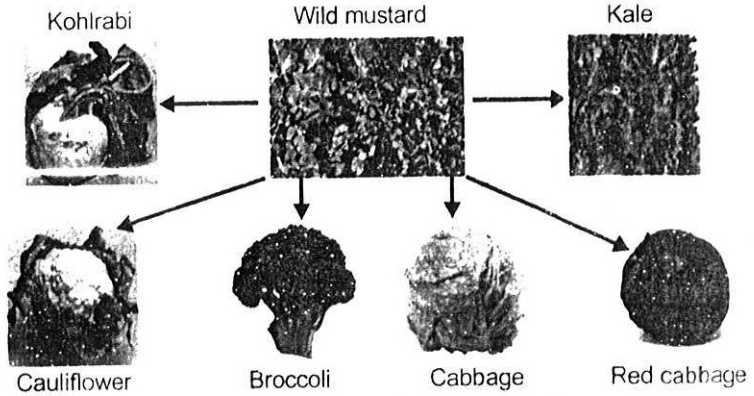


Fig.: Evolution of wild mustard

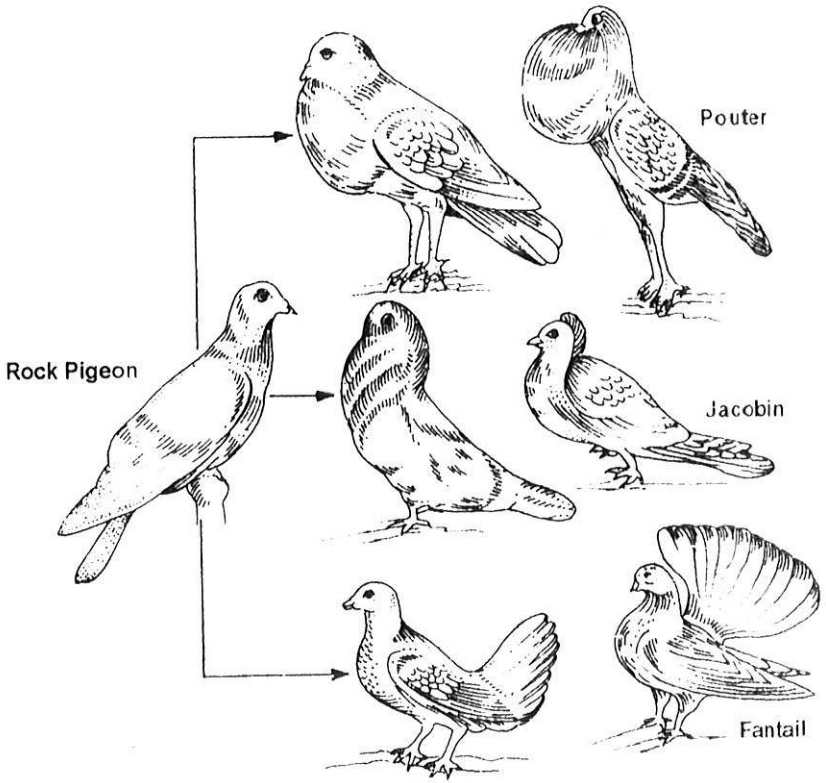


Fig. : Variation among breeds of domestic pigeons.

Ancestry of different breeds can be traced to wild rock pigeon. (Artificial Selection)

Evidences in support of evolution

1. **Morphological and anatomical evidences –**
   - **A. Homologous organs- similar origin and basic structure (function may be different)**
     - ✓ **Indicates common ancestory – divergent evolution**
     - ✓ **Eg vertebrate hearts**
     - ✓ **vertibrates brains**
     - ✓ **four limbs of whale, bat, cheetah, horse and human (all mammals)**
     - ✓ **thorn and tendrils of bougainvillea and cucurbita,**
     - ✓ **phylloclade (stem) of opuntia and stem of any other plant**

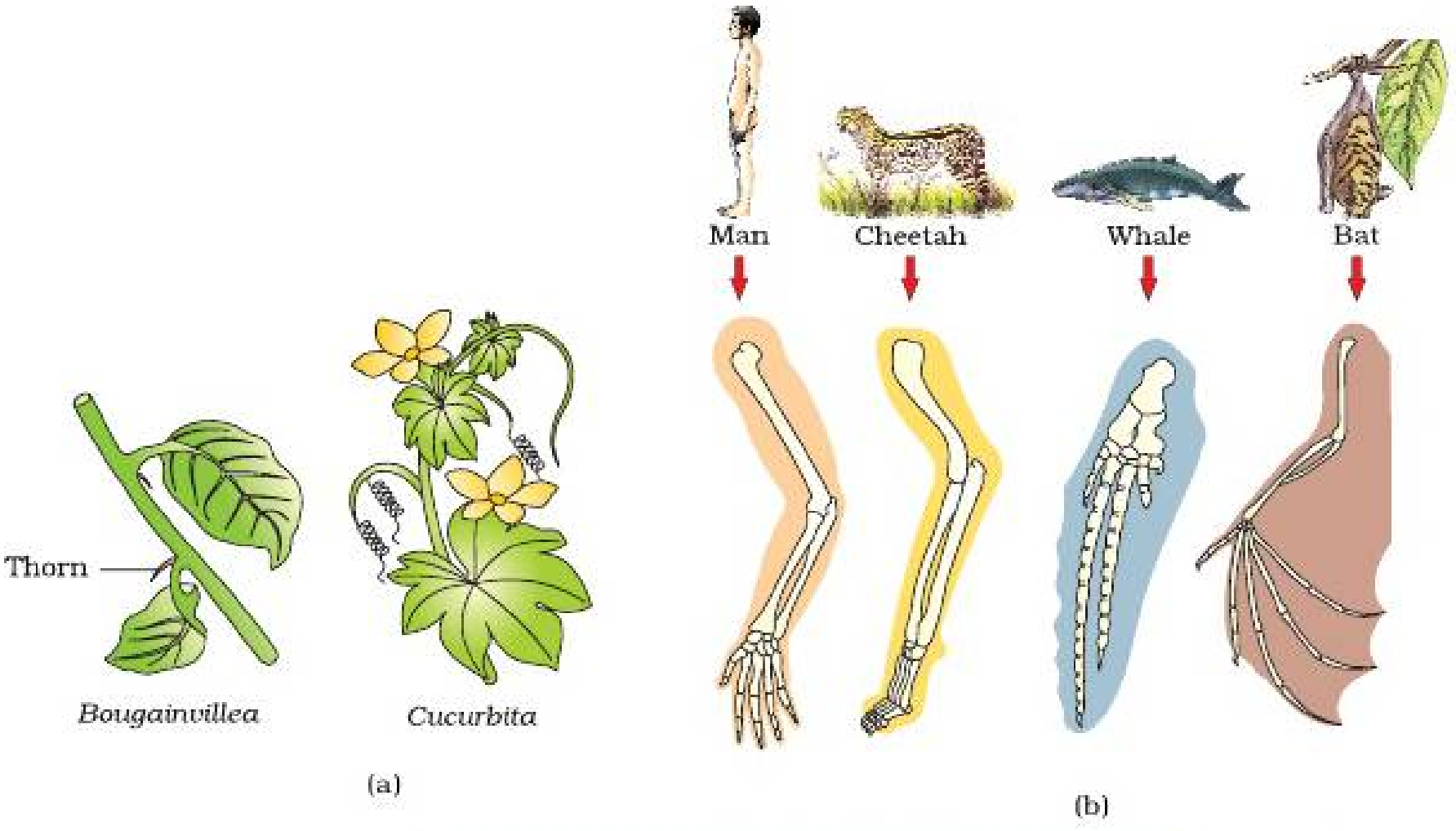


Figure 7.3 Example of homologous organs in (a) Plants and (b) Animals

B. Analogous organs – similar function but different origin

- ✓ **Indicates convergent evolution**
- ✓ **Eg wings in bats/birds and wings in insects**
- ✓ **Eye of an octopus and vertebrate**
- ✓ **Phylloclade (stem) of opuntia and leaf of any other plant**
- ✓ **Potato (modified stem) and sweey potato (root)**
- ✓ **Flippers of penguine (Bird) dolphin (mammal)**
- ✓ **Chloragogen cells of earthworms and liver of vertebrate**

C. **Vestigial organs – rudimentary, non functional, gives idea about common ancestors between organisms**
   - ✓ **Eg- appendix, wisdom teeth (last molar), pinna muscles, nictitating membrane, nipple of male, caudal vertebrate/tail bone**
   - ✓ **Pelvic girdle / hind limbs of pythons and whales**
   - ✓ **Splint bones /reduced digits in horse**

D. **Atavism/reversion – reappearance of ancestral characters**
   - ✓ **Eg – tailed baby , additional teats etc**

E. **Connecting links – shows characters of two different groups**
   - ✓ **Eg. euglena, proterospongia, peripatus, neopilina, balanoglosus, lungfish, latimaria, egg laying mammles etc**

2. **Biochemicals evidence**
   - ✓ **Eg. Trycsin enzyme universal in animals**
   - ✓ **Humans and apes (chimpanzee and gorilla) show similar banding pattern on chromosome and similar Ag-Ab reaction of blood group**
   - ✓ **Blood proteins – man's closest to apes**

3. **Embryological evidence –**
   - ✓ **Recapitulation theory biogenetic law – ontogeny repeats phylogeny by Ernst Haeckel**

4. **Biogeographically evidence - single land massk (pangea), drifted apart, restricted free movement of organism**
   - ✓ **Eg. discontinuous distribution of closely related species**
   - ✓ **restricted distribution**
   - ✓ **Darwin finches (adaptive radiation)**
   - ✓ **Convergent evolution (placental mammal and marsupial)**

Figure 7.5 Variety of beaks of finches that Darwin found in Galapagos Island

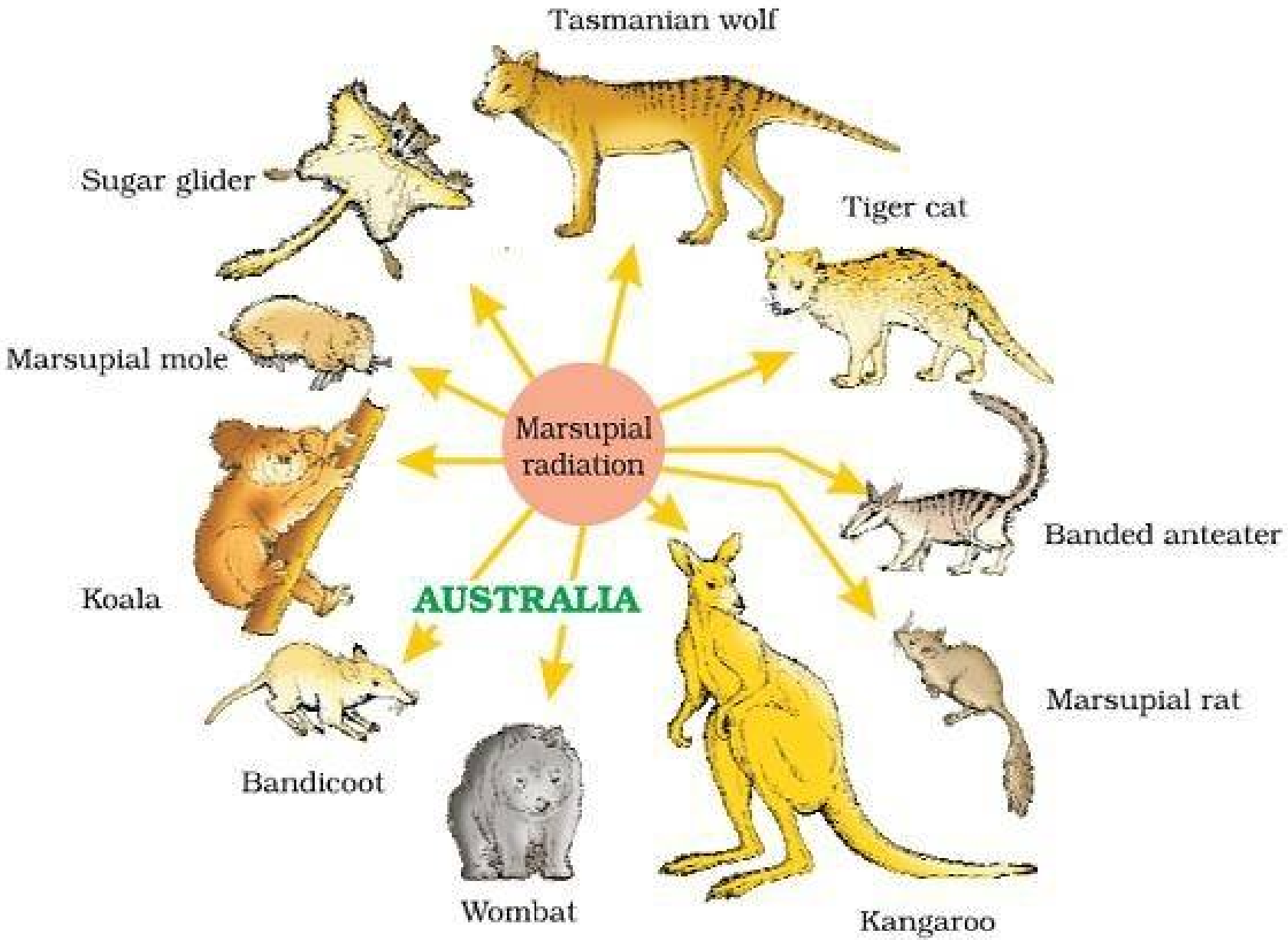


Figure Adaptive radiation of marsupials of Australia

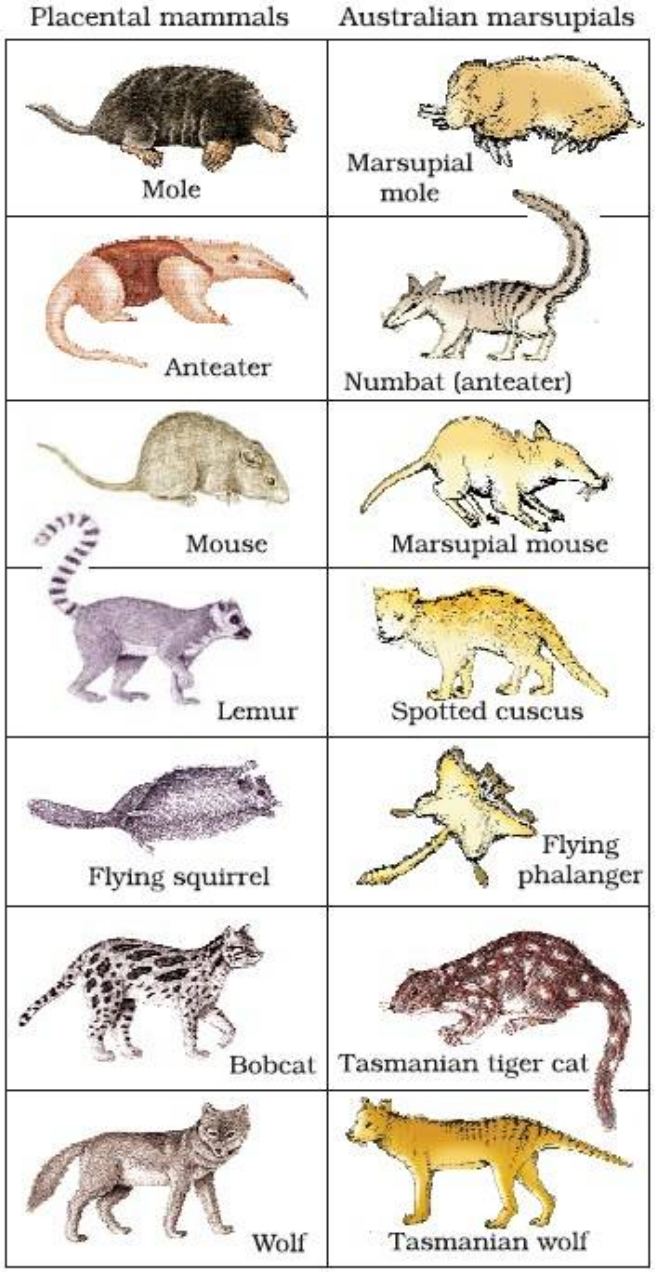


Figure 7.7 Picture showing convergent evolution of Australian Marsupials and placental mammals

5. **Paleontological evidence**
   - ✓ **Study of fossils – palaeontology**
   - ✓ **Father of modern palaeontology – G.Cuvier**
   - ✓ **Most concrete evidence**
   - ✓ **Remains or impressions of hard parts of life forms that are now extinct, found in different layers of sedimentary rocks**
   - ✓ **Different aged rock sediments contain fossils of different life forms who died during formation of the particular sediment rock**

Age of fossils –

a) **Carbon dating methods (C^{14} half life = 5568 years) and C^{12} ratio used (for 1 lac year old fossil), by Libby**
b) **Pottasium – argon method – determine 1.3 * 10^9 year old age of rocks**
c) **Uranium 238 – lead 207 method**
d) **ESR electron spin resonance method - most modern and sophisticated**

ERA	Periods	EVENTS
1. Paleozoic 570 – 245 mya	Cambrian	Precence of invertebrate life. Eg. Trilobite Fossils (extinct Arthropods)
	Ordovician	1st vertebrate (Jaw less fish) originated 350 mya; Bryophyte originated 320 mya.
	Silurian	Origin of pteribothytes plants.
	Devonian	Origin Amphibia ("From lobed-pin" ancestors like Coelocanth fishes); Origin of "Gymnosperms" (as "seed ferns"). Tall pteriodophytes (= tree ferns) covered the face of earth (large forests)
	Carboniferous	Forests of pteriodophytes become subterranean & converted into fossil fuels (wells & petrolelum); Origin of Reptiles [seymouria (amfibia) $\rightarrow$ cotylosauria (ancestral reptile}
	Permian	Origin of Therapsid reptiles. (probable ancestors of mammals) Synapsid $\rightarrow$ Pelycasour $\rightarrow$ Therapsida Reptile Reptile

2. Mesozoic 245-65 mya "The golden age of reptiles	**Triassic**	**Origin of 'Dinosaurs' & mammals simultaneously. Gymnosperms formed the main vegetation of Earth**
	Jurassic	Origin of 'Birds' (From a group of Dinosaurs/ Reptile)
	Cretaceous	Dinosaurs showed ADAPTIVE RADIATIONS i.e. captured all habitats by aquiring extreme structural specializations) Large carnivorous ⇒ Spinosourous T.rex Herbivorous ⇒ Brachisaurous, Icthiosaur. Flying dinosaur ⇒ Pterodon → Origion of dicots (Angiosperms) = Evolution of "Flying insects" At the end of this period, all dinosaur "Suddenly" became extinct.
3. Cenozoic 65 mya – till present	Tertiary	➢ Origin of ancestors of horse, camel & elephants. (= The evolutionary history of these animals has been fully discovered during "Eocene" epoch, the ancestors of horse – Eohippus, originated (size of fox & 4 toes in front leg & 3 toes in hind leg) ➢ Origin of "Prosimian" Primates (=Lemur, Loris, Tarisuis) & "Simian primates (=Monkey) ➢ Origin of "Proconsul" (= Dryopithecus) i.e. common ancestors of both apes & Humans around 20 mya in miocene Epoch.
	Quaternary	"<u>Pleistocene Epoch</u>" ⇒ The age of <u>human evolution.</u>

Important Ages :-

Charlie Told,	→	**Cambrian, Trilobites**
Deepak Finished	→	**Devonian, Fishes**
CA,	→	**Carboniferous, Amphibians**
Joined Dominos	→	**Jurassic, Dinosaurs**
as MR and	→	**Mesozoic, Reptiles**
Completed MBA	→	**Cenozoic, Mammals, Birds, Angiosperms**

- **Geological time scale of earth – divided into era, period and epochs**
- **By the time of 500 mya - invertibrates formed an active**
- **Around 350 mya – jaw less fish evolved**
- **Around 320 mya sea weeds and few plants existed**
- **First organisms to invade land – plants**
- **In 1938 – coelacanth (fish caught in south Africa)**
- **Lobefins (with stout and strong fins, could move on plant and go back to water), evolved into first amphibians (ancestors of modern day frogs and salamanders)**

- **Amphibians evolved into reptiles (lay thick shelled eggs which do not dryup in sun), ancestors of turtles, tortoise and crocodiles**
- **Around 200 mya – some of these reptiles went back into water to evolve into fish like reptiles (eg. ichthyosaurs)**
- **Land reptiles were dinosaurs**
- **Biggest dinosaur - tyrannosaurus rex (20 feet height, huge dagger like teeth)**
- **About 65 mya dinosaurs suddenly disappeared from earth (at the end of cretaceous period of Mesozoic era) - climatic change/evolvement into birds /query**

- **First mammals – like shrews**
- **When reptiles came down mammals took over this earth (viviparous, protect unborn young inside mothers body, more intelligent in sensing and avoiding danger)**
- **Due to continental drift, pouched mammals of Australia survived because of lack of competition from any other mammal**
- **Some mammals live wholly in water – whales, dolphins, seals, seacows etc**
- **Origin and evolution of man**

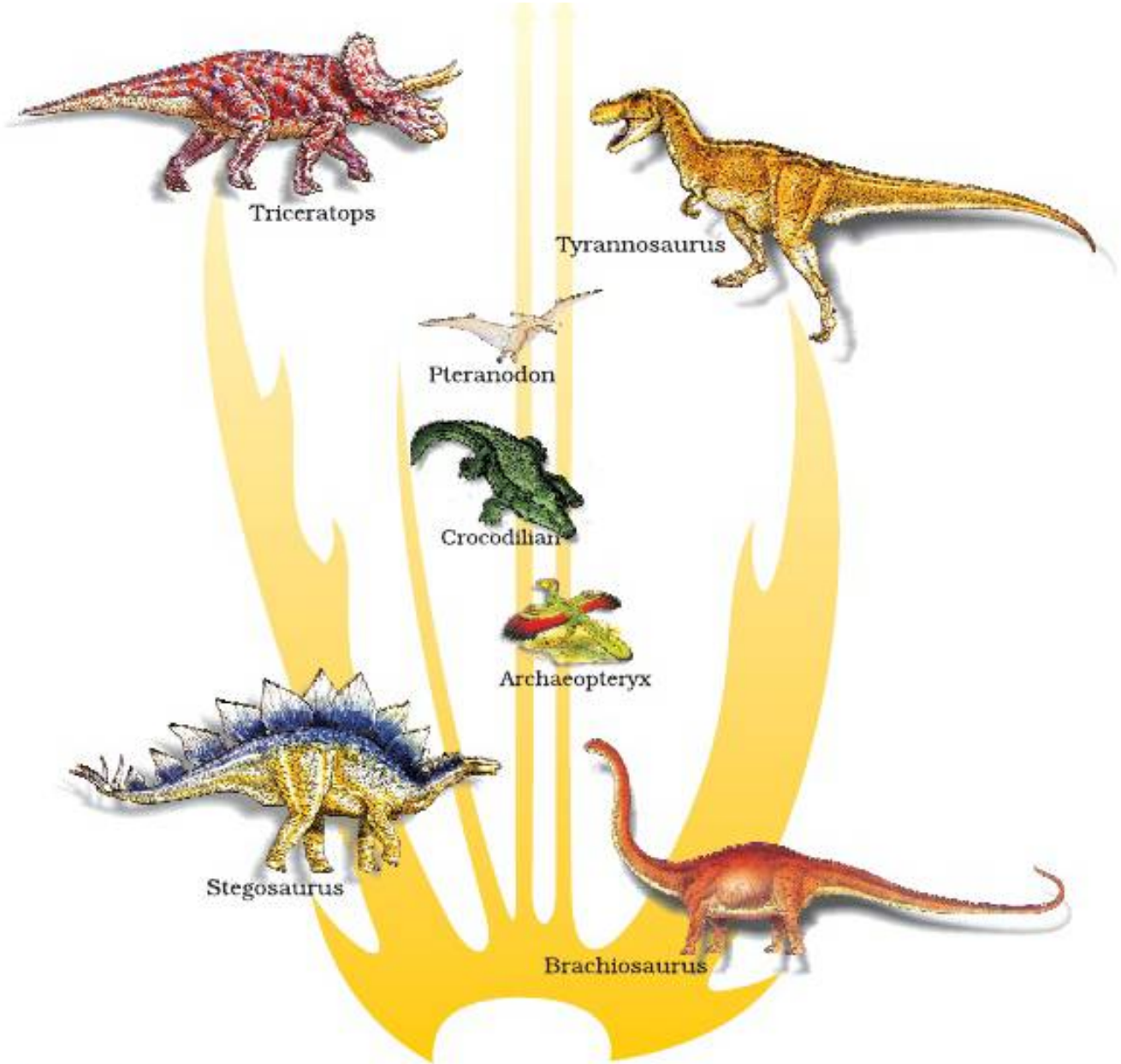


Figure 7.2 A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

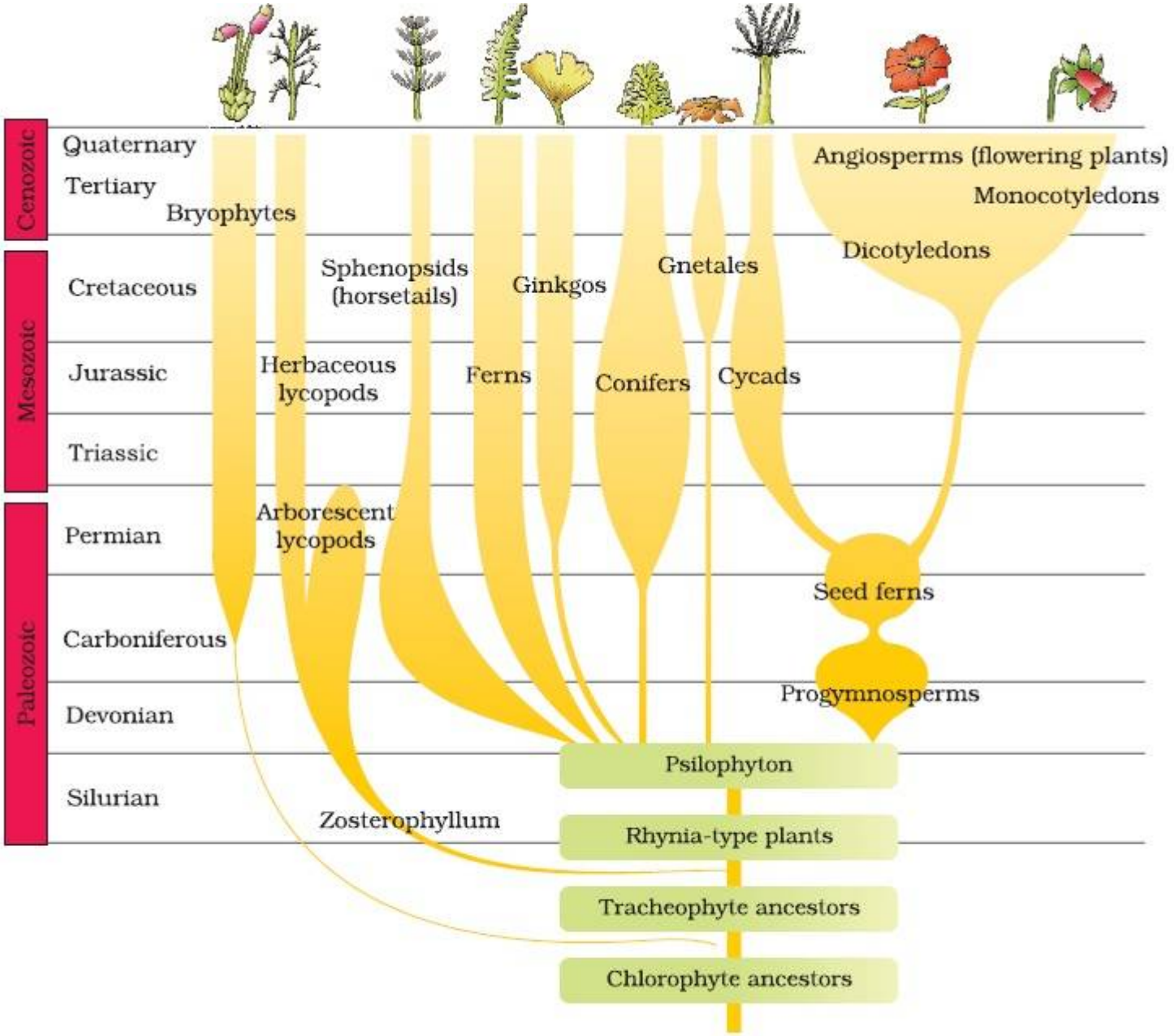


Figure 7.9 A sketch of the evolution of plant forms through geological periods

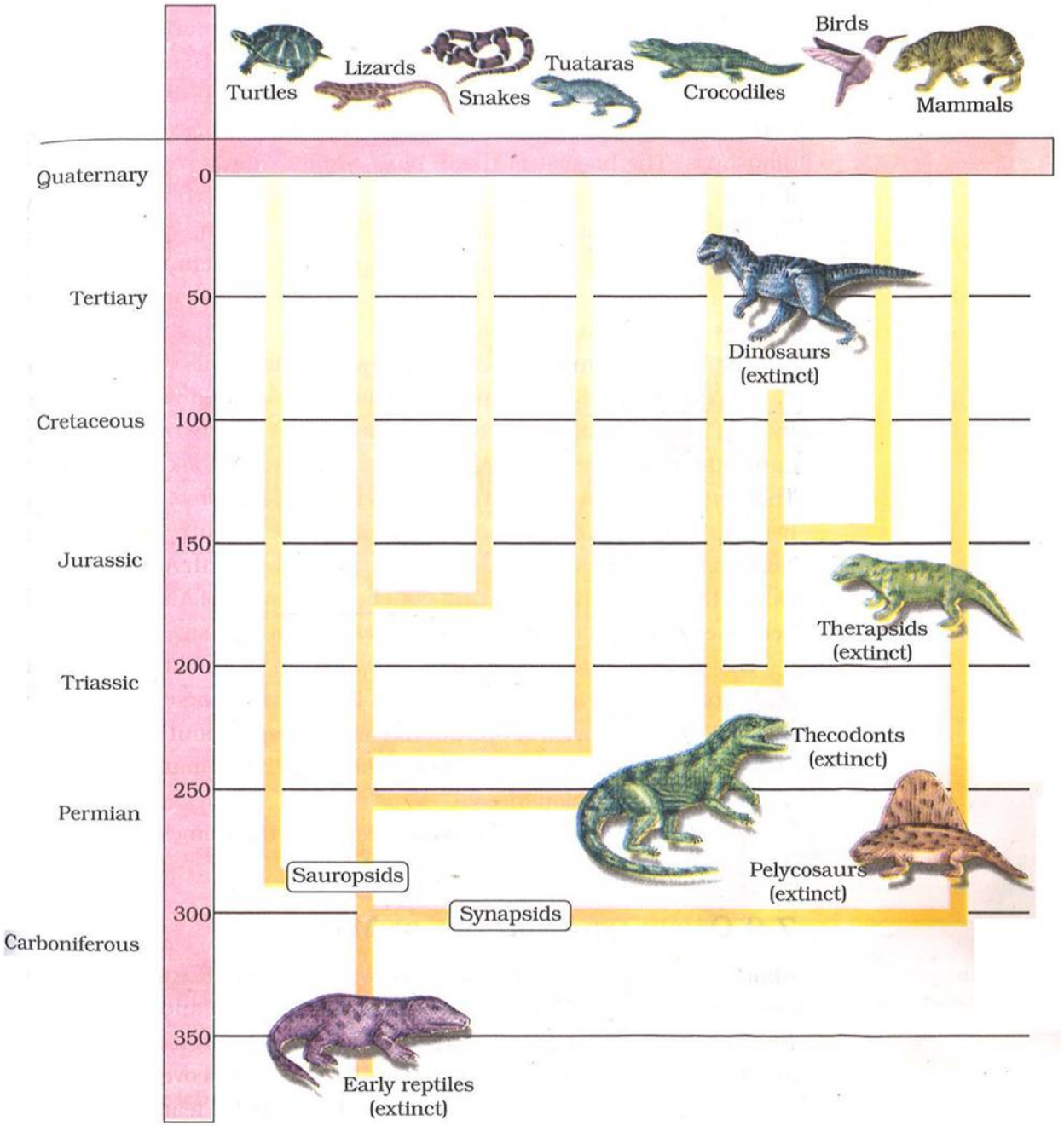


Figure 7.10 Representative evolutionary history of vertebrates through geological periods

Table Human Evolution

S.No.	Human Ancestor	Cranial Capacity	Feeding habits	Other Facts
1.	Ramapithecus sivapithecus (15 mya)	300 C.C.	Mostly Fruit eaters	Fossils discovered from africa & Sivalik range of India. Only the molar teeth were human like.
2.	Austrolopitheus africans (2 mya)	500 C.C.	Mostly Fruit eaters	Famous fossils (from Africa) = Lucy & tuang Baby, first ancestor that walked on 2 legs
3.	Homo habilis (The skilled man 2mya)	700 C.C.	Mostly Fruit eaters	"The toot maker/The nut-cracker" First human ancestor who made tools out of bones & stones
4.	Homo-erectus — Java-man (Pithecanthropus) — Peking man (Sinanthropus)	(1.5 my old) 900 C.C. 1075 C.C.	Non-Vegetarian (Meat-eaters)	First ancestors who used FIRE could run on 2 feet

S.No.	Human Ancestor	Cranial Capacity	Feeding habits	Other Facts
5.	Neanderthal Man (Homo sapiens neanderthalensis) fossils from neander valley of Germany (=1 lac up – to 40,000 yrs back)	1400 C.C.	Hunter & Meat eater	Strong tall (2m right); muscular body; No "lumbar curve" (curved back); prognathus face (=projecting jaws); Raised brow-ridges & less developed chin. • Neanderthal man started using 'primitive form of language' & <u>domestication of dogs</u> • This man used fine tools & weapons • Carried out ceremonial burial of their dead • Note – Neanderthal man was an independent evolutionary line, therefore cannot be considered as the direct ancestor of the modern man
6.	Cro-Magnon man (Homo sapiens fossilis) Fossils (From France 75000 – 15000 yrs ago)	1600 C.C.	Omnivorous	• A lumbar curve was present; Orthognathus face (= flat); no brow-ridges, well developed chin • Cromagnon is the 'direct ancestor' of modern man. Cromagnon created sculptures & cave-paintings/rock- paintings (around 18000 yrs old)
7.	The modern man (Homo sapiens sapien)	1400 C.C. 6 races of Negroids, caucasoids, Red Indians.	Omnivorous Modern man-mongoloids, Australoids, Bush man of Africa.	Only 'Cultural evolution' has changed cromagnon into the modern man because structurally they are same (development of Agriculture, Animal Husbandry, invention of script to write down the language) Stone Age → Copper Age → Iron Age